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Soaring Demands, Shrinking Resources*

The rate of population growth of the United States is greater than that of the world, greater than that of India. There is now a net gain of one person every 13 seconds, nearly 300 every hour, and more than 2 million every year in this country.

It has been estimated that population will grow to at least 190 million by 1975, to well over 200 million by the year 2000.[1]

Since 1900, growth in population has been accompanied by a notable increase in the per capita capacity to consume materials. This has put a heavy drain on our resources of soil, water, timber, and minerals.

Two-thirds of the raw materials processed in our factories come from the soil.[2] Theoretically, soil and forests are renewable resources, but in the light of the facts, we are mining our fields, forests, and water resources at a suicidal rate.

The outlook for our fund resources—the metals, minerals, and fossil energy that feed the insatiable appetite of our industrial society—is even more alarming. Since 1900 the mineral wealth of the nation has been exploited at an increasingly rapid rate. The metallurgic processes of today require rich ores, but the high grade ores of many metals are running out.

The earth's crust and the water of the ocean still contain vast reservoirs of essential minerals. The problem is one of recovery: much of this potential richness cannot be utilized by existing methods. The outlook for the future depends upon how quickly the new science of micro-mineralogy can be developed to permit the working of very low-grade ores.

WHAT PRICE INDUSTRIALIZATION?

During the first half of the twentieth century our population doubled, and the United States passed from a nation almost entirely self-sufficient in resources to one of growing dependence upon others for many essential raw materials. Reviewing the problem in 1950, the Materials Policy Commission had this to say:

> . . . In area after area the same pattern seems discernible: soaring demands, shrinking resources, the consequent pressure toward rising real costs, the risk of wartime shortages, the ultimate threat of an arrest or decline in the standard of living we cherish and hope to help others to attain.

* * *

*This is the second of a series of three issues. The first discussed renewable resources and the third (to be published in 1954) will deal with the qualitative aspects of population change.

> The greatest uncertainty that confronts us all as we attempt to pierce the fog of the next quarter century lies in the unanswerable question, will there we war? . . . If complete world peace, confidence, and prosperity were to bless the world tomorrow, the materials problem would surely not vanish nor necessarily become less severe—for if all the nations of the world should achieve the same standard of living as our own, the resulting world need for materials would increase to six times the present already massive consumption. On the other hand, if today's cold war should erupt into a hot war tomorrow, the pattern of materials demand, and the adequacy of our supplies, would alter in much swifter and more drastic ways. . . .
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> * * *
>
> . . . By 1950—in comparison with the year 1900—we were taking from the earth:
>
> Two and one-half times more bituminous coal.
>
> Three times more copper.
>
> Three and one-half times more iron ore.
>
> Four times more zinc.
>
> Twenty-six times more natural gas.
>
> Thirty times more crude oil.
>
> Indeed, there is scarcely a metal or a mineral fuel of which the quantity used in the United States since the outbreak of the First World War did not exceed the total used throughout the world in all the centuries preceding.[3]

Technology was born of the need to get the riches out of the earth and convert them into materials needed for industry. In the years to come, technology will have to develop substitutes for those minerals now in short supply, and to provide ways for better use of all minerals. The demand for an ever higher standard of living by a rapidly growing population will, as in the past, be translated into an ever higher per capita need for raw materials.

The problem is extremely complex, and space limitation confines this discussion to those raw materials mentioned above. These and other critically scarce raw materials are reviewed in detail in the Report of the Materials Policy Commission.

IRON

Iron is the basic material of our industrial society. Fortunately it is one of the world's most abundant metals since it constitutes about one-twentieth of the earth's crust.

In 1950 the United States consumed about 130 million short tons of iron ore, assuming 50 percent iron content. It is estimated that the need in 1975 will be approximately 200 million short tons. This assumes ore of today's iron content, and increased use of scrap.[4]

The most productive iron ore region in the world is in pre-Cambrian strata surrounding Lake Superior, on the border between the United States and Canada. During the past century, the reserves in Michigan and then Minnesota have provided the needs of this nation. By 1950, more than 65% of all domestic iron ore mined came from Minnesota. The Mesabi Range, that fabulous "inexhaustible" reserve, which was first opened up in 1892, had contributed about 1.5 billion tons of high grade ore by 1950.[5]

The Materials Policy Commission stresses that the output in the future will be at increased cost:

> The high-grade, low-cost ores of the Lake Superior region are likely to ap

proach exhaustion during the next 25 years. Improvements in stripping methods and the use of trucks and conveyor belts have made it possible to remove larger quantities of ore from deeper pits. But ore bodies now being tapped must be stripped to greater depths than before. An increasing share of ore is coming from higher cost operations underground. And, since 1935, a growing portion has required treatment before shipping in order to raise its iron content to the 51 percent to which the steel mills are accustomed. As production is continued, the costs of mining and beneficiation are bound to rise. With expected increases in present estimates of lower cost reserves it is possible that tonnages of ore of the quality now being shipped from the region will not fall off seriously during the next decade. The proportionate contribution of this tonnage to total consumption, however, is certain to diminish, and within the next quarter century, an absolute decline is probable. Deposits controlled by some of the steel companies will be depleted less rapidly than those supplying others. But a serious long-run problem confronts all the mills now served by Lake Superior ore.

There is little prospect that increased output from other regions in the United States can contribute substantially to increased demands. Mines in the Northeast will continue to serve as a minor source of supply. Deposits in the West and in the Southwest, while relatively small and scattered, should suffice to support an expansion of steel production in these areas. Deposits in the vicinity of Birmingham are larger. But these ores are mostly mined underground and must be concentrated or mixed to yield a good blast-furnace charge. Ores suitable for mixing are running out, and those now coming into use are difficult to beneficiate. Expanded output in the Birmingham area will be accompanied by rising costs. On the whole, the steel industry in the United States must depend increasingly upon deposits of lower grades around Lake Superior and upon imports from Canada and overseas for future additions to its supply of ore.[6]

The table below shows that relatively little high-grade ore remains in this country:

RESERVES OF IRON ORE IN THE UNITED STATES[7]
(billion short tons)

Region	50% iron and over	35 to 50% iron	25 to 35% iron	Total
Lake Superior	1.8	2.8	66.2	71
Northeast			3.3	3
South		2.0	10.5	12
West	0.6	0.1	0.2	1
Total	2	5	80	87

In 1950 Secretary of the Treasury George M. Humphrey, then president of M. A. Hanna Company, summed up the nation's need for iron in these words:

We [the steel industry] have had an exploration program for thirty years all over the Western hemisphere. The steel industry is expanding, the reserves of domestic ores are declining, and in a national emergency we would need more ore reserves. This country is built on a steel economy. There's no fear of running out of iron—we can use lower-grade ores. But it's very expensive. It's a matter of relative cost. A matter of cost.[8]

So the search for high grade ores, which can be processed in existing furnaces at lower costs than the low grade ores still in the earth, goes on. In cooperation with the nations involved, our steel industry is pouring millions of dollars into developments in northern Canada, at Knob Lake on the border of Quebec and Labrador, and in Venezuela's Orinoco River valley. Railroads are being constructed through the wilds of mountainous terrain, and air fields and river ports are being built in isolated places to bring the ore out for the steel mills of this nation.

A recent issue of the *Wall Street Journal* carried a graphic story of the Venezuelan development:

Ciudad Piar, Venezuela—Giant power shovels will begin arriving here this month in preparation for the first assault on the world's richest mountain of iron.

This mountain is the fabulous Cerro Bolivar ore deposit owned by U. S. Steel Corp. Though it won't start yielding ore till early next year, Cerro Bolivar is already criss-crossed with roads blasted from the red hillside. You can ride to the top in a jeep and walk on a crust of ore averaging 230 feet thick which makes engineers' eyes pop. In this four-mile-long, 4000-feet-wide deposit, some 500 million tons of ore lie exposed to the air waiting to be scooped up.

The tapping of Cerro Bolivar's riches will mark a major step in the carving-out of a new economic empire here in the wild valley of the Orinoco River. This development has much meaning for the U. S. economy. With U. S. iron ore reserves dwindling, the Orinoco valley by 1955 may be supplying American steel mills with nearly 10% of their ore.

All told, this valley contains an estimated two billion tons of iron ore. That's about double the remaining reserves of high-grade ore in the Lake Superior area, the biggest U. S. source of ore.

* * *

Fly over it and you see a land of rolling hills and open meadows, through which course fast-running streams. Ride through it and you might easily convince yourself you are in a very green American West, a land of magnificent distances and wide open spaces. You come on lonely cattle ranches of adobe, each place miles from its nearest neighbor. You see long-horned cattle browsing in meadows and rangy horses pasturing.[9]

In 1890, the Mesabi Range also was a wilderness gem, with lush forests teaming with wild-life:

. . . From the North Star camp near the site of Buhl a virgin forest stretched to the Wright, Davis camp near where Cooley is now, a distance of twenty-five miles. Both white and red, or Norway, pines of majestic proportions, as well as considerable hardwood, covered the area. I remember seeing partridge, deer, and one moose on our trip. Beyond the logging camp our way lay through a region that had been logged for the most part. As usual, I took my camera along and kodaked for my amusement, little dreaming then how rare authentic pictures of the Mesabi Range in its pristine condition would become even in my lifetime. I am glad that I saw those beautiful trees before they vanished. For anyone who knows only the modern appearance of the Mesabi Range, it would be impossible to form a true mental picture of the original sites of Hibbing, Buhl, Chisholm, Eveleth, and Virginia. Few areas in the United States have been so completely altered by man.[10]

The nature of the raw materials problem which this country faces today is highlighted by the fact that the rape of the Mesabi wilderness has yielded up to now three-quarters of the total amount of ore that today's technologists see in the Orinoco lode — "the world's richest mountain of iron." The successive depletion of these irreplaceable pockets of mineral wealth means rising costs of production and cumulating scarcity of the basic metals of industry.

COPPER

With copper, the situation is even more acute. Rapid exploitation is now touching the bottom of the barrel of a fund resource once considered inexhaustible. While steel blast furnaces demand and continue to get iron ore of 50 percent iron content, the average grade of copper ore mined in 1950 was 0.9 percent—compared with 5 percent in 1900. Capital investmen

per ton of copper produced has increased substantially. It is not now economically feasible to mine much of the remaining—and by no means abundant—lower grade copper ores in the earth.

All known disseminated deposits made commercial by mass mining methods are now thought to be in production or in process of development. Indeed, so complete has been the exploitation that at the end of the current defense program the productive capacity at almost every significant copper deposit in the United States will represent the optimum capacity for that deposit. Nor does there appear to be much chance that further technological progress in mining would increase reserves significantly by making lower grade deposits profitable, through lowering the minimum or cut-off grade of workable ore. The present loss of copper in milling is apparently at an irreducible minimum of 1 to 2 pounds per ton of ore. If the grade of ore being milled were lowered much more, the percentage recovery would drop to an uneconomic level under present prices. But more important is the view that there is not a large quantity of copper left in ore below the current cut-off grade of roughly 0.5 percent. In any event, it is most likely that a number of important producing companies in this country will find it more advantageous to continue to expand their operations abroad, where they have extensive holdings that are richer and cheaper to operate, than to mine such low-grade deposits at home.[11]

A century ago all copper the United States required was brought to this country from Chile as ballast in ships returning from California via Cape Horn. By 1925, the United States was the world's greatest exporter of copper. By 1950, this country was the world's greatest importer.

In 1950, the United States imported 448 thousand tons of copper. Mines in this country produced 907 thousand tons; three times the production of 1900.

Demand by 1975 has been estimated at approximately 2.5 million tons. To meet that demand imports may well exceed 1950's by half a million tons.

It has been said that since the turn of the century more copper has been mined and dispersed as non-recoverable waste than was used by the entire human race during five thousand years. Technology seems to have lagged in that area, even though it has developed important substitute materials, namely aluminum, magnesium and plastics. Copper will very likely be replaced, except in those processes where it is absolutely essential, usually for its chemical properties rather than as a metal. For example, more than 101 thousand tons of crystalline copper sulphate were produced by U. S. industry in 1951. It will continue to be a constituent of bronzes and other alloys having special properties, and to be an essential in agricultural and medical technology.

ZINC

Zinc is another tool of modern technology whose supply in this country does not nearly equal demand. Zinc is important to industry because of its relatively low cost and its chemical and mechanical properties. Its five principal uses are in galvanizing, die cast-

ing, pigments and salts, brass and bronze, and rolled zinc. These together account for nearly 90 percent of the total consumption.

In recent years domestic production has averaged about 620,000 tons a year. Scrap has supplied an additional 75,000 tons, and imports have amounted to about 380,000 tons.

Experts feel that even with improved recovery and future discoveries, domestic production can hardly be expanded beyond 700,000 tons a year. By 1975, U. S. demand is expected to grow to 1.6 million tons. With an anticipated scrap recovery of 100,000 tons, imports must more than double to 800,000 tons to meet this quota.[12]

BITUMINOUS COAL

Coal is one non-renewable resource whose demand-supply ratio is reversed. The reserves now and for the rest of this century are plentiful. As the nation's most abundant fossil fuel, coal is the source of energy most likely to be tapped in the years ahead as oil and natural gas reserves are depleted. This assumes that solar energy still remains unharnessed and that atomic energy will be available in only a limited way for industrial purposes. This discussion is confined to the use of coal as a source of energy. It does not consider what the drain on reserves might be should coal be more widely used than it is now as a raw material for the chemical industry.

The Industrial Revolution got its start on the energy from coal. Coal provided most of the energy for our industrial plants until the turn of the century when oil began to tincture the nation's industrial bloodstream. Natural gas began to be used about 1925. Since then, the use of coal as a source of energy has proportionally declined. Yet total consumption is up by 60 percent.

It has been estimated that during the next 25 years, consumption of coal will increase by another 60 percent—to above 800 million tons a year—although coal's total share of the energy market will continue to decrease during that time. As long as oil and natural gas are in adequate supply, coal will remain a secondary source of energy. But when petroleum begins to run out, coal can furnish the basis for synthetic liquid and gaseous fuels.[13]

Depletion of competitive fuels continues at a merry rate, and this could eventually reverse the cost ratio so that the higher relative cost of petroleum and natural gas will work advantageously for coal as a source of energy:

> This Nation's abundant reserves of coal make coal a major long-range source of fuel and raw materials for a wide variety of industries. Sooner or later several major United States industries will have to sink their tap roots deeply into our coal reserves, as did the railroads earlier. Steel has long been rooted to coal and will need increasing amounts. The electric power industry too has been a major customer but now shows signs of becoming a far larger one and a major collaborator toward putting coal

more abundantly into use in a variety of ways. Likewise the fast-growing chemicals industry, long tied indirectly to coal through the route of coke and the steel industry, holds promise of becoming a much greater user along with the oil industry, which when need and technology are ripe, can turn to coal conversion to secure an important portion of the nation's liquid fuel supply. Nor is it inconceivable that the natural gas industry may some day turn heavily to coal as a source of product to fill its pipelines.

* * *

. . . Tremendous possibilities exist for improving the techniques of coal production, preparation, transportation, and utilization. Some already are sufficiently advanced to justify large-scale investments by the coal industry if it could be assured of a sustained high demand.[14]

PETROLEUM AND NATURAL GAS

By 1900 petroleum had begun to be a significant source of energy in the United States, contributing slightly less than one-tenth of the energy supply. Since then an increasing amount of petroleum has been consumed each year. Natural gas, principally obtained as a by-product of oil production, has during the past 30 years replaced coal and oil in certain areas. By 1950 natural gas supplied a fifth of the energy used in the United States and oil about a third.

Petroleum is essential to modern warfare and two world wars made staggering demands on oil reserves of this country. The rate of consumption for domestic and industrial uses increases each year. By 1950, the annual consumption of petroleum had risen to 2.4 billion barrels: That means sixteen barrels per year for every man, woman and child in the land. Estimated 1975 consumption has been placed at 5 billion barrels per year.

As with copper, the United States was once the world's largest exporter of petroleum products. But by 1950 we were drawing on the oil resources of other countries —to the extent of about half a million barrels a day, almost 200 million a year. Every barrel imported displaces a barrel which would be taken from reserves at home, stretching our dwindling domestic supplies just that much.

That new discoveries of oil in the United States still keep ahead of extractions does not alter the fact that we have just so much oil and no more. The rate of depletion of our oil reserves will depend on the cost ratio of oil, gas, and coal—and on the cost of obtaining liquid fuels from coal and oil shales:

What appears fairly certain, then, is that the Nation's liquid fuel supplies by 1975 will come from three main sources: domestic crude, imports, and synthetic oil. The question that cannot now be answered is: What part of the total liquid fuels will each of these three sources supply to the Nation in 1975? The answer will be fashioned largely by the behavior of relative costs of domestic crude, imports, and synthetics, provided competitive market forces are allowed reasonably free rein.

* * *

If United States domestic production is to keep pace with the projected growth of consumption over the next 25 years it would have to increase at a rate of about 3 percent per year—to about 4½ billion barrels in 1975, allowing for a proportionate rise in imports. To sup-

port this growth, new reserves proved each year must on the average replace the production of that year plus a net addition of 3 percent of total reserves to permit the latter to increase in proportion to the 3 percent growth in annual production. Since reserves average about 13 years' annual production, 3 percent of total reserves equals about 40 percent of annual production. New discoveries and developments must accordingly run about 1.4 times annual production. . . .[15]

The rapid growth of natural gas as an important source of energy in this country has occurred largely since the 1920's when huge quantities were tapped in drilling for oil. In 1920, natural gas supplied about one-twenty-fifth of the energy used. In 1950 it supplied about one-fifth, a total of 6.3 trillion cubic feet were consumed. Consumption by 1975 has been estimated at 15 trillion cubic feet.

Today, the southwest is the main source for natural gas. From there it has been piped to the Atlantic Seaboard and more recently to California. Well over half of the gas marketed is consumed in the general area in which it is produced. Natural gas will always be, to a considerable extent, a by-product of petroleum, so these two fuels will increase or decline in importance together.[16]

WHAT OF TOMORROW?

The philosophy underlying the conservation movement is that each generation is a trustee and conservator of the earth's riches. The nation's resources are a great part of its heritage. The depleted state of many of our resources emphasizes what our reluctance to adopt a generally accepted national conservation ethic has cost in terms of our national heritage. That is why past, present, and *future* resource utilization deserves the attention of every American.

Yet, there are those who seem to urge the profligate use of resources as a virtue. Their argument holds that in the earth's crust and in the sea there are vast quantities of all the essential materials needed by modern industry and agriculture. For example, several of the Rocky Mountain states are underlain by a layer of phosphate rocks several hundred feet thick, which contain a virtually inexhaustible source of agricultural phosphate and considerable quantities of various other essential elements such as aluminum, iron, and potassium. The sea, which is now our main source of bromine and magnesium, might be called a liquid "inexhaustible ore," since it contains many essential elements and compounds. Most of these are now beyond reach of profitable extraction.

Those who take this optimistic position see the problem as basically one of human ingenuity and technical skill. They believe that these and other sources will be tapped by the genius of our descendants when the need becomes desperate enough. In effect, they maintain that we are handing down not a mortgage with an eventual due date, but a challenge to be met.

Theoretically, the future outlook for energy supplies looks as bright as the sun, which has continued in business since long before the fossil

fuels were laid down in the depths of the earth more than two hundred million years ago. The sun radiates a prodigious amount of energy to the earth. If it could be trapped in adequate quantities the problem of a source of energy would be permanently solved.

Today solar energy is utilized to a limited extent. About 25 percent of the electric power generated in the United States comes from this source, in the form of hydroenergy. Some physicists have suggested that huge batteries of windmills might be built in strategic locations as electric generators. Many architects believe that solar energy will heat the houses of the future. One house in Massachusetts has an ingenious method for trapping and storing the heat of the summer sun for use during the winter months. Water for household purposes is sometimes heated by the sun in areas of intense sunshine.

An acre of land in the central United States receives some 20 million kilocalories of energy per day from the sun. About 265 million kilocalories of solar energy per person per day are available in the United States. The problem is to trap it.[17]

Chlorophyll is still the most efficient energy-trap available. In the cells of plants chlorophyll fixes the sun's energy in starch, sugar, and cellulose. This process captures only about one-tenth of one percent of the solar radiation received on an acre of ground. The energy-trap of the future will have to multiply this efficiency many times.

Photosynthetic and photochemical processes for trapping solar energy that are more efficient than chlorophyll will most certainly be discovered. But whether their efficiency will be great enough to really harness the sun to turn the wheels of industry and to warm the homes of the earth's people is a question. Practical application may still be far in the future.

Nor is there any prospect that atomic energy will become a source of cheap, inexhaustible energy. According to Dr. Lawrence Haftstad, one of the country's leading atomic physicists and member of the Atomic Energy Commission, "Another widely held misconception is that atomic energy will provide cheap power for the next generation. Power from uranium is not going to be cheap soon. Because nuclear power is, and is likely to remain, expensive, its first practical applications will be military."[18]

Atomic power generates heat to make steam, which turns a dynamo. Hence, atomic power would actually be used as electric power. Dr. Haftstad discusses the economics of conversion in these words: "But we already know, roughly, the cost of these reactors, and calculations indicate that the capital investment necessary to build a reactor large enough to produce electric power would be enormous. And each kilowatt hour of energy produced would be quite expensive . . . thus the atomic energy program seems likely to include production of electric power as a by-product of the production of weapons for war."[19]

If the military demand for plutonium continues, then by-product power may be economically feasible. Only in this way is there any early prospect that atomic energy can compete with coal as a source of electricity.

While uranium is more common than gold and silver it is not an easy metal to concentrate into usable supplies. It has been suggested by some distinguished atomic scientists that enlightened and prudent nations would save this uranium for special uses rather than burning it as a marginal substitute for coal.

TIME vs. SWELLING TIDE OF PEOPLE

The difficulty with the cornucopia theories—which have as a common denominator a limitless future base whether in terms of land, forests, water, minerals or metals—is that at the present time at least they are all pure theory.

But the multiplication of the earth's people is a dynamic which is startling to comprehend. It shows little tendency to stop while new processes are being invented or perfected to provide food and other needs.

Every 24 hours there are 70 thousand more people on this planet. It is within the power of modern medical technology to greatly increase that daily increment of people almost over-night by applying in "coiled" countries like India and China medical and public health techniques that reduce the high death rates but leave the high birth rates unchanged. Ceylon's experience with a DDT anti-malaria campaign demonstrated how easily and cheaply a population explosion can be ignited in those countries that have not yet felt the full impact of modern medicine.

It has been stated that a six-fold increase in the present rate of resource consumption would result if the 2.5 billion people in the world today were all to enjoy a standard of living comparable to that of the United States. This is certainly an understatement. Should population double by the year 2000, as some demographers consider possible, the resource consumption rate would reach staggering proportions.

The industrial machine of our era demands huge supplies of raw materials and energy. Every improvement in living levels of people anywhere on our planet, and every step toward industrialization of underdeveloped countries result in higher per capita capacity to consume materials.

The rapid rate of population growth continually increases the demand base, and barring disasters world population will continue to grow at a very rapid rate for at least a generation.

The challenge is clearly defined. Future generations must possess the ingenuity and intelligence to provide the technical skills that our increasingly complex industrial society will demand as the resource base continues to shrink.

They must also possess the courage and wisdom to apply technology to the population problem as

well as to the resource utilization problem. Methods of population control which are acceptable to people of various cultures are needed and wanted now.

Unless technology is applied to control the birth rate as well as the death rate, it is not likely that the world will gain the breathing spell needed to develop a rock-seawater-sunlight economy which could nurture five billion people.

Can the people of the world meet this surpassing challenge—and in time?

ROBERT C. COOK, *Editor*

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